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Contents

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VOL. 22, SEC. F. JULY, 1944 NUMBER 4

DRIED WHOLE EGG POWDER

XIII. EFFECT OF HEAT TREATMENT ON COLOUR[1]

BY W. HAROLD WHITE[2] AND G. A. GRANT[3]

Abstract

Egg powder from two Canadian plants was heated at temperatures from 26.7° to 60.0° C. (80° to 140° F.). Samples were removed for quantitative colour measurements after periods of three hours to seven days. Initially the powders from the two sources differed significantly with respect to both brightness and colour quality. However, their behaviour with heat treatment was essentially similar. Little change in either total intensity or colour quality was noted at temperatures below 35.0° C. (95° F.). Above 35° C. appreciable changes in both brightness and colour quality occurred; the magnitude of these changes increased with increase in temperature and time of treatment. The total intensity decreased, indicating a general darkening of the powder. The amount of light scattered in the green region of the spectrum decreased, while that in the red increased. Some change was also observed in a portion of the violet region.

Introduction

Certain observations have indicated that Canadian dried egg powders are lighter in colour than those from other sources. Such differences presumably are due at least in part to variations in the colour of the liquid egg as a result of different feeding practices in different countries. However, there is little doubt that manufacturing conditions, including time and temperature factors, also exert some influence on the colour of the product. Furthermore, it was suspected that light-coloured powders reflected minor changes more readily than darker powders from other countries. Since temperature at all stages of production and handling has been shown to be an important factor affecting quality in other respects (1, 2, 3), the present study was undertaken to assess the effect of heat treatment on the colour of egg powder.

Samples of egg powder may differ from one another with respect to either or both of two attributes of colour, namely total intensity or brightness, and chroma or colour quality. Brightness is determined by the ability of the sample to scatter all components present in the incident light. Variations in hue, on the other hand, arise from differential scattering of the incident light in one or more wave bands by individual samples.

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Materials and Procedure

As described in an earlier paper of this series (2), egg powders collected from two Canadian plants were heated rapidly to and maintained at 26.7°, 35.0°, 43.3°, 51.7°, and 60.0° C. (80°, 95°, 110°, 125°, and 140° F.). Samples were removed for colour measurement after periods of 3, 6, and 12 hr.; and 1, 2, 3, 4, 5, 6, and 7 days. These conditions were chosen with the primary object of assessing the effect of various cooling practices on several attributes of quality including colour.

Objective colour measurements were made with a photo-electric colour comparator developed previously in these laboratories for use on meat (4, 5). This instrument permitted measurement both of the total amount of light scattered by egg powder and of that scattered in each of nine bands of the visible spectrum.

Results

Colour Intensity or Total Brightness

The results are shown in Tables I and II, and in Fig. 1. Because of the large amount of data and the relatively minor differences in brightness, statistical treatment of the results was necessary. An analysis of variance (Table I) showed that differences in temperature, time of heating, and the

TABLE I

ANALYSIS OF VARIANCE FOR THE EFFECT OF VARIOUS HEAT TREATMENTS ON THE BRIGHTNESS OF DRIED EGG POWDERS SECURED FROM TWO CANADIAN PLANTS

Variance attributable to:	D.f.	Mean square
Temperature	4	942.1**
Time	9	170.1**
Plants	1	2275**
Temperature × time	36	44.4**
Plants × temperature	4	3.422**
Plants × time	9	1.097
Plants × temperature × time	36	0.5893
Duplicate error	100	0.1729

** *Indicates 1% level of statistical significance.*

source of the powder all had statistically significant effects on the colour intensity or brightness of the powder. The magnitude and direction of these changes are shown in Table II. The mean brightness, as averaged over all other conditions, decreased with increased temperature or time of heating; these differences were greatest between the three highest temperatures, and during the first three days of heating. The powder from Plant I was brighter than that from Plant II.

The results are shown in greater detail in Fig. 1. In general there was little change at the lowest temperature and progressively greater decreases with time at the higher temperatures. It is of importance to note that the

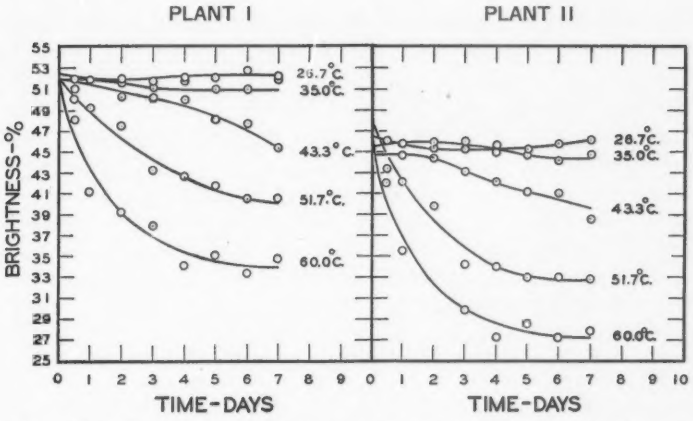

FIG. 1. *Effect of various heat treatments on the colour intensity or total brightness of egg powders from two Canadian plants.*

TABLE II

EFFECT OF VARIOUS HEAT TREATMENTS ON THE MEAN VALUES OF THE BRIGHTNESS OF DRIED EGG POWDERS SECURED FROM TWO CANADIAN PLANTS

Factor	Mean brightness[1]	Necessary difference[2]
Temperature, °C.		
26.7	48.9	
35.0	48.4	
43.3	46.7	0.35
51.7	42.2	
60.0	37.4	
Time, days		
0.13	49.2	
0.25	48.4	
0.50	47.7	
1	46.1	
2	44.8	0.50
3	43.3	
4	42.5	
5	42.1	
6	41.7	
7	41.5	
Plant		
I	48.1	
II	41.4	

[1] *Mean brightness for all other conditions over the whole experiment.*
[2] *Necessary difference required to exceed 5% level of statistical significance.*

behaviour of powders from different sources was essentially similar. Differences between powders from the two plants were approximately of the same

magnitude at all temperatures, while similarity of behaviour was even more noticeable for the differential effects of plants with time. Thus, the darker powder from Plant II exhibited the same general behaviour under the conditions studied as the lighter powder from Plant I.

The average differences between powders exposed to the minimum and maximum conditions of temperature and of time of treatment were not much greater than the average difference between powders from the two sources (Fig. 1 and Table II). From this it may be inferred either that factors associated with plant practice other than the rate of cooling, possibly the conditions of drying, have an important influence on the brightness of egg powder or that the initial liquid egg differed in some manner affecting colour intensity.

Chroma or Colour Quality

While differences between powders from the two sources and changes induced by heat treatment were evident in certain colour bands (Table III) their magnitudes were usually small, thus requiring analyses of variance to assess their significance (Table IV). Fig. 2 shows these changes more clearly with respect to differences between plants and between extremes of time and

TABLE III

EFFECT OF VARIOUS HEAT TREATMENTS ON THE MEAN VALUES OF THE COLOUR OF DRIED EGG POWDERS SECURED FROM TWO CANADIAN PLANTS

Factor studied	Mean scatter[1], %								
	Band 1	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7	Band 8	Band 9
	3850 – 4340 Å	4340 – 4580 Å	4580 – 4870 Å	4870 – 5250 Å	5250 – 5560 Å	5560 – 5840 Å	5840 – 6140 Å	6140 – 6440 Å	Above 6440 Å
Temperature, °C.									
26.7	3.63	6.52	8.57	15.0	15.1	25.3	11.7	7.00	7.18
35.0	3.52	6.62	8.59	15.0	15.0	25.4	11.7	7.07	7.20
43.3	3.33	6.68	8.72	15.1	14.8	25.2	11.8	7.08	7.30
51.7	2.93	6.60	8.79	14.7	14.3	25.4	12.1	7.38	7.71
60.0	2.81	6.71	8.79	14.4	13.8	25.4	12.3	7.59	8.16
Time, days									
0.13	3.34	6.69	8.47	15.0	15.2	25.1	11.9	7.06	7.23
0.25	3.53	6.56	8.56	14.9	15.0	25.5	11.8	7.07	7.05
0.50	3.55	6.74	8.55	15.0	14.9	25.3	11.8	7.00	7.22
1	3.49	6.55	8.68	15.0	14.7	25.4	11.9	7.12	7.35
2	2.92	6.68	8.69	14.8	14.7	25.5	12.0	7.29	7.63
3	3.22	6.45	8.84	15.0	14.4	25.3	12.0	7.30	7.62
4	3.33	6.42	8.79	14.6	14.5	25.3	12.0	7.35	7.71
5	3.18	6.80	8.75	14.7	14.3	25.3	12.0	7.29	7.82
6	3.02	6.78	8.84	14.7	14.3	25.2	12.1	7.39	7.81
7	2.88	6.71	8.82	14.8	14.2	25.4	12.1	7.37	7.67
Plant									
I	3.34	6.73	8.80	15.0	14.9	25.3	11.7	7.05	7.16
II	3.14	6.53	8.58	14.6	14.3	25.4	12.2	7.39	7.86

[1] *Mean scatter for all other conditions over the whole experiment.*

temperature. Egg powder from Plant II scattered less light in the violet and more in the red regions of the spectrum than that from Plant I. It will be

TABLE IV

ANALYSES OF VARIANCE FOR THE EFFECT OF VARIOUS HEAT TREATMENTS ON THE COLOUR OF DRIED EGG POWDERS SECURED FROM TWO CANADIAN PLANTS

Variance attributable to:	Degrees of freedom	Mean square								
		Band 1	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7	Band 8	Band 9
		3850 – 4340 Å	4340 – 4580 Å	4580 – 4870 Å	4870 – 5250 Å	5250 – 5560 Å	5560 – 5840 Å	5840 – 6140 Å	6140 – 6440 Å	Above 6440 Å
Temperature	4	5.1**	0.17	0.45	3.3**	10.7**	0.47*	2.8**	2.5**	7.1**
Time	9	1.2**	0.33	0.36	0.48*	2.4**	0.27	0.25*	0.42**	1.5**
Plants	1	2.0*	2.1**	2.3**	7.9**	14.4**	0.52	9.1**	5.9**	24.4**
Temperature × time	36	0.39	0.38	0.26	0.49**	0.54	0.20	0.21*	0.16**	0.30**
Plants × temperature	4	0.31	0.09	0.28	0.21	0.51	0.08	0.17	0.16*	0.08
Plants × time	9	0.54	0.40	0.16	0.40	0.13	0.13	0.06	0.10	0.13
Plants × time × temperature	36	0.38	0.28	0.22	0.20	0.34	0.14	0.11	0.06	0.06
Duplicate error	100	0.14	0.13	0.11	0.13	0.08	0.11	0.06	0.05	0.08

* *Exceeds 5% level of statistical significance.*
** *Exceeds 1% level of statistical significance.*

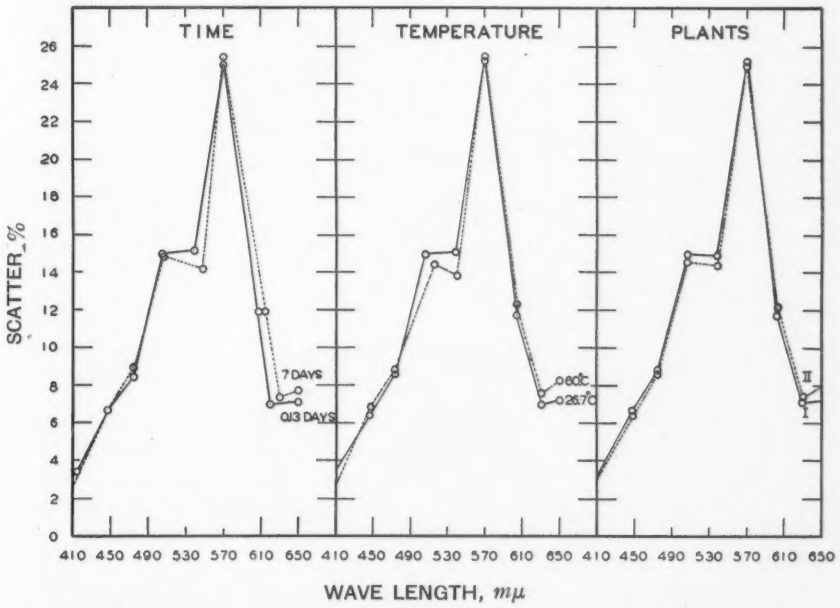

FIG. 2. *Effect of source and of period and temperature of heat treatment on the colour quality of egg powder.*

remembered that the powder from Plant II was generally darker, as shown by brightness measurements (Table II).

From Table IV it may be seen that the source and the temperature and period of treatment each had statistically significant effects on the colour in all bands except 2, 3, and 6. The greatest changes occurred in Bands 1, 4 and 5, and 7 to 9. It may be noted here that the values for Band 1 show that a definite decrease occurred in the amount of light scattered in a portion of the violet spectral region. However, such changes have little practical significance since visual acuity is low in this region. Bands 5 (5250 to 5560 Å) and 8 (6140 to 6440 Å) were chosen for more detailed presentation as typical of regions in which larger and more important changes occurred.

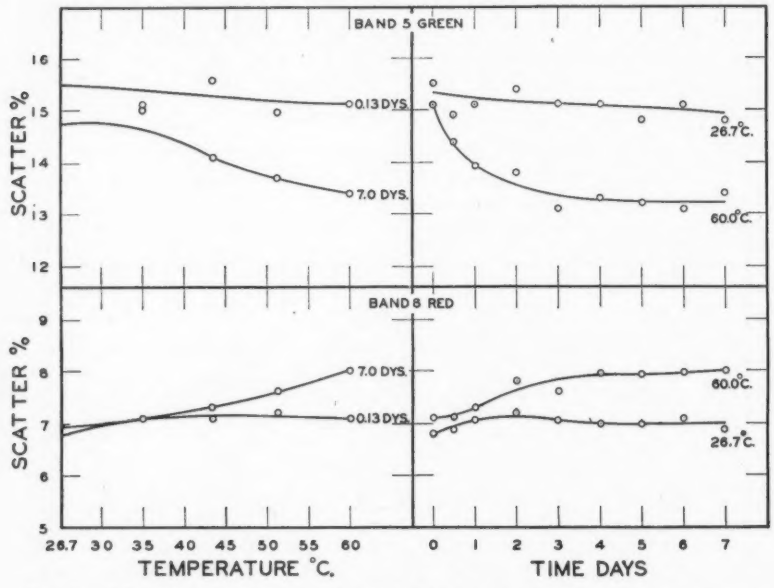

FIG. 3. *Effect of the temperature and period of heat treatment on the colour of egg powder in the spectral regions of 5250 to 5560 Å and 6140 to 6440 Å.*

Fig. 3 shows the changes in Bands 5 and 8 at selected times and temperatures. In terms of colour these changes correspond to a reduction in the green component and an increase in red scatter, in response to increasing time and temperature. Visually, the typical yellow colour of egg powder decreased, and the brown colour increased with increasing severity of heat treatment.

In both Bands 5 and 8, as shown by Fig. 3, the colour changes at the maximum temperature studied appear to be approaching equilibrium before the end of the period of treatment was reached.

Conclusions

From the foregoing results it is apparent that, under adverse time and temperature of storage, the colour of egg powder is affected with respect to both intensity and colour quality. The powders darkened, accompanied by a decrease in the green portion of the spectrum, and an enhancement of the red scatter. Above 35° C., these adverse colour changes assumed more serious proportions as time and temperature of treatment were increased.

No comment is offered on the mechanism of the changes in colour quality; though the fact that three separate colour bands were affected suggests that specific pigments were involved in these changes.

Acknowledgments

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DRIED WHOLE EGG POWDER

XIV. EFFECTS OF LOW TEMPERATURE, LOW MOISTURE CONTENT, CARBON DIOXIDE PACK, AND COPPER CONTAMINATION ON KEEPING QUALITY[1]

By M. W. Thistle[2], W. Harold White[3], Margaret Reid[2], and A. H. Woodcock[4]

Abstract

As shown by objective tests of quality, egg powder slowly deteriorated even at temperatures as low as −40° C. Low moisture content had a marked preservative action, but powders containing 1.4% volatile materials suffered some deterioration when held at 37° and 48° C. The use of a carbon dioxide pack afforded some measure of protection against heat deterioration, particularly on the solubility of the powder.

Copper contamination had no demonstrable effect on quality, as measured by potassium chloride and fluorescence values, on powders stored at 21° C. for three months, even in the presence of oxygen. The fat fraction showed no evidence of peroxide oxygen development.

Introduction

In the course of work previously reported (7, 10, 11) several points were suggested for further investigation. It was considered of interest to assess the effects of lower moisture content (10) and lower storage temperatures (11) than had been used previously, since these two factors appeared to be most important in lengthening storage life. A carbon dioxide pack showed promising preservative action (11) and merited more detailed examination. Finally even low grade egg powders showed marked resistance to oxidative changes (7): however, in view of the notable effect of copper in accelerating oxidative changes in dried milk (2) a study was indicated on the effect of copper contamination of egg powders. The present series of experiments was designed to extend previous information on all these points.

1. Quality Changes in Egg Powder Stored at Low Temperatures

Since egg powder deteriorated somewhat at 7.1° C. (45.0° F.) (11), information was sought on the quality changes, if any, occurring at still lower storage temperatures.

The egg powder used was from a commercial source and had an initial moisture content of 4.2%; moisture measurements (6) showed no increase during storage and handling. All operations previous to storage were carried

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out at 7.1° C. Samples of powder were sealed in tin cans, and stored at −40.0°, −17.8°, and 4.4° C. (−40.0°, 0.0°, and 40.0° F.) for periods of one, two, four, and eight months. Quality changes were followed by means of potassium chloride values (6), fluorescence measurements (3, 4, 5, 6), and palatability ratings (4, 6).

Results

The results are shown in Table I. On the basis of the potassium chloride values, no particular effect is evident at the end of four months' storage; however, at the end of eight months, all samples had deteriorated, particularly at the highest temperature. It is evident that some deterioration took place even at −40.0° C.

TABLE I

QUALITY CHANGES IN EGG POWDER STORED AT LOW TEMPERATURES

Measurement	Storage temperature, °C.	Storage period, months					Replicate error
		Initial	1	2	4	8	
Potassium chloride value, %	−40.0	69.6	70.5	66.7	68.9	62.8	1.2
	−17.8	68.0	70.0	69.6	70.0	61.7	
	4.4	67.8	69.4	67.2	68.8	54.7	
Fluorescence, units	−40.0	15.0	17.0	17.8	17.9	20.6	0.5
	−17.8	15.2	16.9	17.6	18.1	21.8	
	4.4	15.0	16.6	18.4	19.0	24.5	
Palatability ratings (6-man panel)	−40.0	7.7	7.9	8.0	7.8	8.2	0.7
	−17.8	7.6	7.9	8.0	—	8.3	
	4.4	7.6	8.0	7.3	8.3	8.7	

These results were confirmed by the fluorescence values; moreover this more sensitive test gave some evidence of deterioration even after one month's storage at these low temperatures.

The palatability test, as used here, was not sensitive enough to detect these minor differences in good quality powders. This is in agreement with previous work (6).

It is concluded that good quality egg powders deteriorate slowly even at temperatures as low as −40.0° C.

2. Effect of Low Moisture Content on Keeping Quality

In an earlier communication (10) it was shown that lowering the moisture and volatile content of egg powder improved its keeping quality, the lowest moisture and volatile content used being 2%. The present experiment was designed to test the efficacy of levels below 2%.

The moisture content of a sample of commercial egg powder was reduced by methods already described (10) from an initial value of 4.4% to 1.4%.

Samples of powder at both normal and low moisture levels were stored in tin cans for 30 days at 37.2° C. (99.0° F.) and for 15 days at 47.8° C. (118.0° F.). Fluorescence measurements were made at three-day intervals during these storage periods.

Results

The results are presented in Fig. 1. It can be seen that fluorescence development was much slower in powder at 1.4% moisture than in similar powder containing 4.4% moisture. However, even at the low level of 1.4% moisture, egg powder suffers deterioration by heat in a relatively short time. It may be inferred that reduction of the moisture level of commercial powders to the lowest practicable level will be useful in improving the keeping quality of dried eggs, but that this process will by no means render the product imperishable.

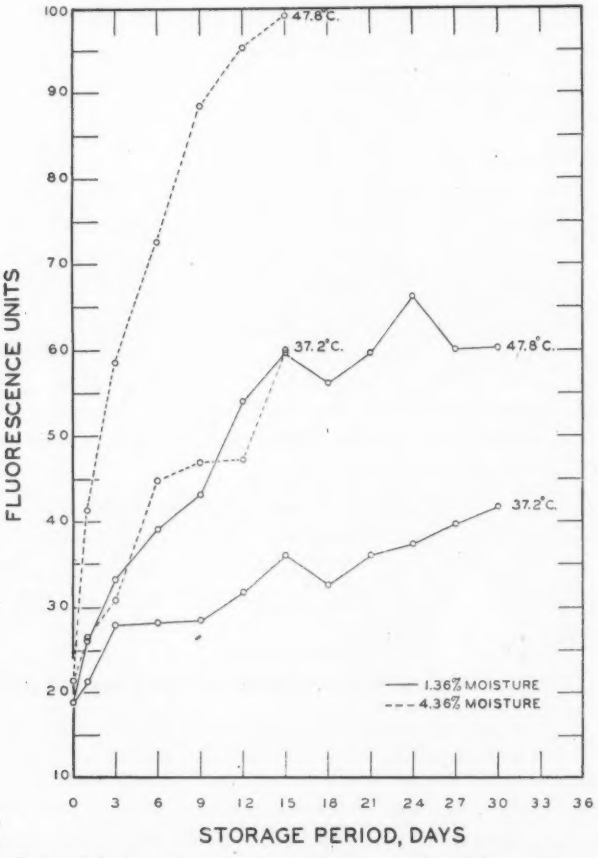

FIG. 1. *Storage behaviour of egg powders with average and with low moisture contents.*

3. Effect of Carbon Dioxide on Keeping Quality

Earlier work indicated that carbon dioxide exerted a beneficial action on the keeping quality of dried eggs (11). The present experiment was designed to test this effect in greater detail.

Commercial dried egg powder of 3.7% moisture content was gas-packed with carbon dioxide in tin cans. Air and gas-packed samples were stored at 23.9° C. (75.0° F.) for 1, 2, 4, 8, 16, and 32 wk.; and at 47.8° C. (118.0° F.) for 1, 2, 4, 8, 16, 32, and 64 days. Quality was assessed by means of potassium chloride values, refractometric values (9), fluorescence values, and palatability ratings. At the end of storage, analyses showed the following gas composition in the headspace:

Gas	24° C.	48° C.
Carbon dioxide	98.1%	97.6%
Oxygen	0.1%	0.2%
Nitrogen	1.8%	2.2%

Results

The results are presented in Fig. 2. The potassium chloride values indicate that the solubility of egg powder was retained better at both storage temperatures by packing in carbon dioxide. Confirmatory evidence is offered by the refractometric values and the greater cake volume (Fig. 3) exhibited by carbon-dioxide–packed samples.

In the powders held at 23.9° C. for eight months, fluorescence development in gas-packed samples was retarded. However, in the samples held under more rigorous conditions (47.8° C.), fluorescence development was retarded for the first few weeks of storage only, after which it was enhanced by the presence of carbon dioxide. The palatability of gas-packed samples was judged superior when the powder was held at 23.9° C., however at 47.8° C. the palatability ratings were higher for the first half of the storage period only, after which they fell to the same low level as that of the air-packed powders.

It was previously noted that solubility and flavour quality normally were correlated (6); apparently the association is disrupted by the use of carbon dioxide, suggesting that chemical changes take place in gas-packed powders at high temperatures.

It may be noted that packing egg powder in an atmosphere of carbon dioxide resulted in lengthening the storage life when ordinary temperatures were used. At higher storage temperatures the solubility of the powders was preserved, but the flavour quality was retained for a short period only.

It is concluded that the use of carbon dioxide in packaging dried egg powder retards heat deterioration, and in conjunction with other preservative measures may be useful in prolonging the storage life of dried egg.

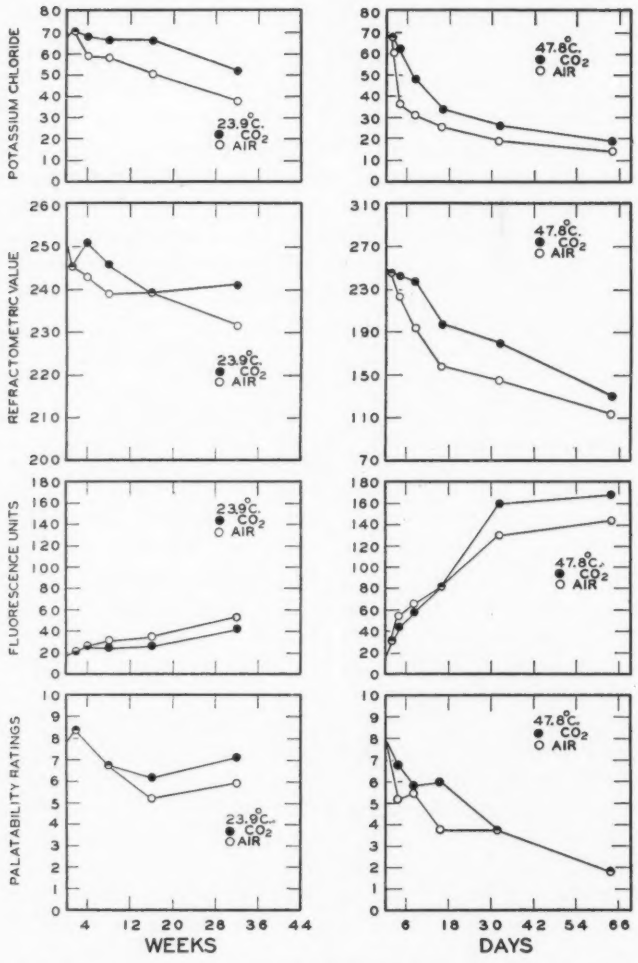

FIG. 2. *Storage behaviour of egg powders packed in air and in carbon dioxide.*

4. Effect of Small Amounts of Copper on the Stability of Vacuum-Dried Whole Egg Powder

Since all egg-drying plants are not provided with stainless steel equipment, some information was desirable on the influence of small amounts of copper in dried egg, such as might occur from contamination with copper or brass equipment.

Copper contamination was secured by pouring egg melange through a double thickness of new, fine-mesh copper screen, just prior to drying by the vacuum-ice method. Six batches of melange were treated by passing 0, 1,

PLATE I

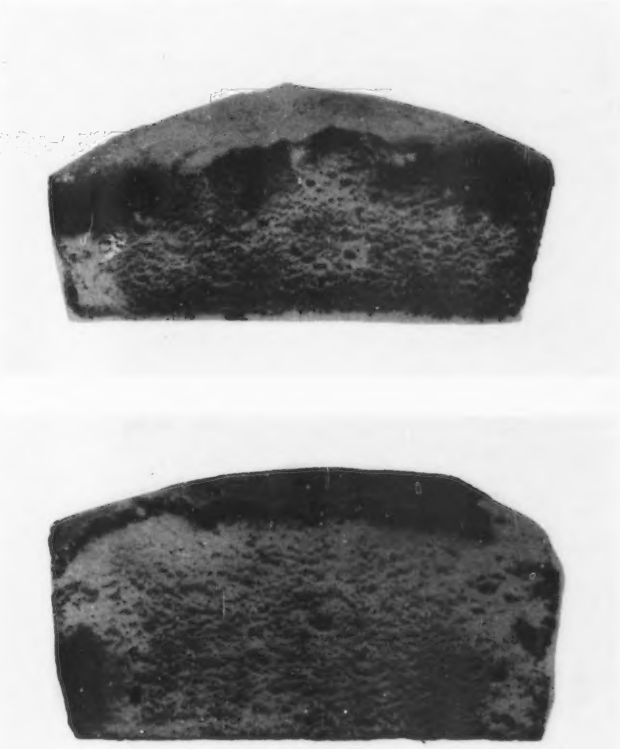

FIG. 3. *Baking tests on egg powders held for eight months at 23.9° C. The upper loaf was made from carbon dioxide packed material and the lower from powders stored in air.*

ERRATUM

In the caption for Fig. 3, for "upper" read "lower" and for "lower" read "upper".

2, 4, 8, and 16 times through the copper screen. (One passage gave approximately 1½ p.p.m. of added copper in the resulting dried egg.) Samples of dried egg from each batch were canned in both air and oxygen and stored at 21.1° C. (70.0° F.) for three months. At the end of storage, quality of the samples was assessed by means of potassium chloride and fluorescence values. Deterioration of the fat fraction was assessed by peroxide oxygen determinations (8).

The method used for determining copper consisted of wet oxidation (digestion with nitric, sulphuric, and perchloric acids) of dried egg samples to produce inorganic copper salts. The residue was treated by a tentative A.O.A.C. method (1) for determining copper in water analyses, except that visual colour comparisons were replaced by measurements made on the Evelyn photoelectric colorimeter.

Results

The results are given in Table II. Considering the differences between methods of packing, the mean potassium chloride values show that oxygen-packing accelerated deterioration. The difference between mean fluorescence values is small. The uniformly lower moisture content of the oxygen packed powder is due to repeated evacuation of the tins during gas-packing.

TABLE II

STABILITY OF EGG POWDER CONTAMINATED WITH COPPER AND STORED THREE MONTHS AT 21.1° C.

Sample No.*	Copper, p.p.m.	Packed in air			Packed in oxygen		
		Moisture, %	Potassium chloride value	Fluorescence value	Moisture, %	Potassium chloride value	Fluorescence value
0	1.8	3.68	69.1	20.8	2.96	57.8	23.0
1	3.3**	3.16	74.4	21.8	3.02	54.8	23.2
2	4.4	5.12	65.2	25.4	4.74	49.4	25.6
4	7.8**	4.74	62.6	23.4	3.96	50.8	22.8
8	13.8	3.02	68.6	21.6	2.68	58.8	21.0
16	25.6	3.22	66.3	22.0	2.86	54.4	23.0
Mean	—	3.82	68.6	22.5	3.37	54.3	23.1

* *Number of passages of egg melange through a copper screen prior to drying and storage.*

** *Calculated values.*

NOTE—*The potassium chloride value and fluorescence methods were not available when this study was begun. However, the fluorescence of fresh vacuum-ice-dried egg powder is usually 12 units, and the potassium chloride value is usually about 80%.*

Differences due to the level of copper contamination were negligible. Oxygen appeared to be equally harmful in the presence and absence of copper; and the lowest potassium chloride values and the highest fluorescence values occur in Samples 2 and 4, rather than at the higher copper levels. Moreover, these effects can be accounted for by the higher moisture contents of Samples

2 and 4. The marked effect of moisture content on quality of egg powder has been demonstrated (10).

No evidence could be obtained of any peroxide oxygen formation. This is in agreement with previous work (4, 7).

It is concluded, therefore, that copper contamination under these conditions has little or no demonstrable effect on the stability of egg powder.

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FLUORESCENCE DEVELOPMENT IN VARIOUS FOOD PRODUCTS[1]

By Jesse A. Pearce[2]

Abstract

Fluorescing substances developed in the following materials during storage: high protein foods, represented by dried whole milk powder, dehydrated pork, and soya flour; high carbohydrate foods, represented by dried banana flakes and dried parsnips; and a mixed foodstuff, represented by ration biscuits.

The only change occurring in stored shortenings was a decrease of fluorescing substances in hydrogenated linseed oils. Serum extracted from rancid butter had a higher fluorescence value than serum from fresh butter. In substances containing a high proportion of fat, fluorescence values bore little relation to deterioration as assessed by peroxide oxygen determinations.

Fluorescence tests were unsatisfactory for dried milk powders and soya flour. However, they may prove useful as a measure of quality for dehydrated pork, dried banana, dried parsnips, ration biscuits, and butter. Fluorescence measurements may also detect reversion in hydrogenated linseed oil shortenings.

Introduction

The ultimate criterion of quality in a foodstuff is its acceptability when consumed and for this reason many investigations involving food quality require panels of selected persons trained to taste the material and estimate its quality. This subjective procedure entails various errors, e.g., when samples are numerous the tasters may become bored and careless long before the conclusion of the experiment. Therefore, the use of objective tests that do not vary with time is highly desirable.

A fluorescence measurement proved to be a useful measure of the quality of dried whole egg powder (6, 8), and also gave an indication of the storage history of wheat germ (2). Further investigation indicated that protein deterioration contributed to fluorescence development in dried egg powder (3). It seemed of interest, therefore, to measure fluorescence changes during the storage of high protein and other foodstuffs. The high protein foods selected for this survey were dried whole milk powder, dehydrated pork, and soya flour; the high carbohydrate foods, dried banana flakes and dried parsnips; and 12 shortenings were used as representing fatty foodstuffs. Two types of ration biscuits were also investigated, since they are essentially a mixture of each of the three foregoing classes of foodstuffs.

Work on dried eggs had shown that it was possible to have high fluorescence values and poor quality in the product, without the appearance of fat deterioration as assessed by peroxide oxygen determinations (9). Therefore, peroxide oxygen measurements were included in quality tests made on foods containing appreciable quantities of fat.

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Materials and Methods

The products selected were from a variety of sources. The dried whole milk used consisted of drum- and spray-dried powders from one company and a spray-dried sample from another company. The dehydrated pork was prepared in these laboratories. The soya flour was a commercially available full fat product. The high carbohydrate foods (dried banana and dried parsnips) were also available commercially.

The shortenings studied were of the following types: hydrogenated vegetable, from two sources; stabilized hydrogenated vegetable, from three sources; compound vegetable, compound vegetable containing 0.05% of a wheat germ oil antioxidant,* and a stabilized compound vegetable; mixed animal and vegetable, from two sources; and a hydrogenated linseed oil.

The biscuits used were from two companies; one contained soya flour as a source of protein, the other, dried milk powder.

For dried milk powder and emergency ration biscuits, the storage temperatures used were 23.9°, 32.2°, and 47.8° C. (75°, 90°, and 118° F.); and for soya flour, dried banana, and dried parsnips, 23.9°, 37.8°, and 47.8° C. (75°, 100°, and 118° F.). The storage temperatures for dehydrated pork were 23.9° and 37.8° C. (75° and 100° F.) and for the shortenings, 37.8° C. (100° F.) only. All samples were stored in air in closed containers to prevent moisture changes.

The methods of measuring fluorescence were somewhat similar to those described for dried egg powder (6, 7). For example, 1 gm. of defatted milk powder was extracted with a 10% potassium chloride solution and made up to 250 ml. to bring the reading within the range of the scale on the Coleman photofluorometer. Dried bananas and dried parsnips were not defatted prior to extraction with the protein solvent. The shortenings were dissolved in petrol ether (1 gm. in 50 ml.) and the fluorescence of the resulting solution determined. The Coleman photofluorometer was standardized with quinine sulphate solutions as described for dried whole egg powder (6). The fluorescence readings are recorded in photofluorometer units.

Palatability scores were determined for reconstituted dried milk and reconstituted dried pork by panels of 14 tasters. The ratings applied were based on scores from 10 to 0; 10 corresponding to an excellent fresh product. Rancidity in the shortenings was assessed by a panel of four persons who smelled each sample and scored it as rancid or sweet. Dried bananas, dried parsnips, and soya flour were not tested organoleptically.

Peroxide oxygen determinations were made on foodstuffs in which the fat content was appreciable. The method used was similar to that described for pork fat (10). Peroxide oxygen values are recorded as ml. 0.002 *N* thiosulphate per gram of fat.

* *Formula C, Viobin (Canada) Ltd., Montreal.*

Results

High Protein Foodstuffs

Changes in organoleptic score and fluorescence values of stored milk powders are shown in Fig. 1. Fluorescence measurements were less satisfactory for milk powders from the Company *X*. The fluorescence value of both drum- and spray-dried powders from this company remained constant for about eight weeks and then increased, the increase being most rapid at the highest tem-

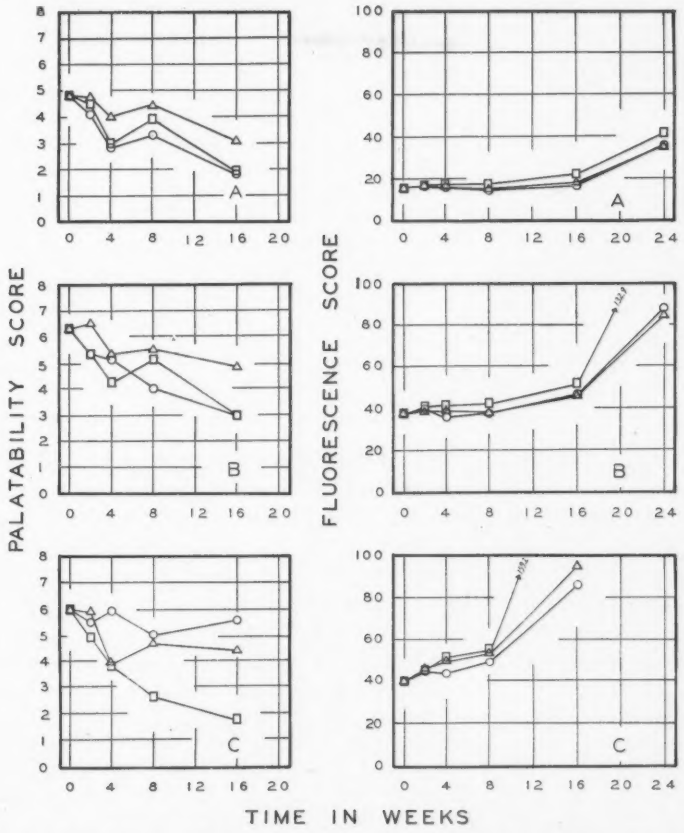

FIG. 1. *Palatability and fluorescence changes occurring in stored milk powders: A—drum-dried, Company X; B—spray-dried, Company X; C—spray-dried, Company Y. Storage temperatures:* □ *47.8° C. (118° F.);* △ *32.2° C. (90° F.);* ○ *23.9° C. (75° F.).*

perature. The low fluorescence values of the drum-dried powder is probably a result of protein coagulation occurring during this drying process (11). For these powders there was no significant association between palatability and fluorescence values, but the over-all linear correlation for spray-dried

powder from Company *Y* was −0.950**. It is unlikely that fluorescence measurements will be of value in predicting milk powder quality although it is interesting to note that fluorescing substances increase on storage.

The results of peroxide oxygen measurements on fat extracted from the stored milk powders are given in Table I. Peroxide oxygen increase did not

TABLE I

PEROXIDE OXYGEN VALUES (AS ML. 0.002 *N* THIOSULPHATE PER GM. OF EXTRACTED FAT) IN STORED WHOLE MILK POWDERS

Material	Storage temperature		Peroxide oxygen value after storage for		
	°C.	°F.	8 wk.	16 wk.	24 wk.
Drum-dried—Company X	23.9	75	5.8	19.7	18.4
	32.2	90	0	0	11.0
	47.8	118	0	0	19.5
Spray-dried—Company X	23.9	75	1.6	6.4	18.8
	32.2	90	0	3.2	14.7
	47.8	118	0	12.8	30.8
Spray-dried—Company Y	23.9	75	0	18.9	43.0
	32.2	90	0	0	22.4
	47.8	118	0	55.5	37.8

occur in any of the powders until after eight weeks' storage and bore no relation to fluorescence development. Peroxide oxygen values indicated a peculiar phenomenon occurring in dried milk powders, i.e. the peroxide oxygen values were much smaller at 32.2° C. (90° F.) than at the other two temperatures. Also, samples from Company *X* stored at 32.2° C. (90° F.) had higher palatability scores than those stored at 23.9° and 47.8° C. (75° and 118° F.). This phenomenon is receiving further attention.

Fluorescence determinations were made on dehydrated pork, prepared in these laboratories (4). It was observed that samples subjected to prolonged drying periods had fluorescence readings of 30 to 70 photofluorometer units while those dried more quickly had values of 15 to 20 photofluorometer units. These results suggested that dehydrated pork would develop fluorescing substances as deterioration proceeded. Fig. 2 shows the results of measurements on stored dehydrated pork. Fluorescing substances were formed during storage and in greater quantities at the higher temperature. A linear correlation ($r = -0.794$**) was observed between fluorescence value and palatability score; it is therefore possible that fluorescence values may prove useful as a measure of quality of dehydrated pork.

Peroxide oxygen development in this material exhibited unexpected behaviour. High values were reached after a short period in storage. These

** *Exceeds 1% level of statistical significance.*

values exceeded the level generally associated with rancidity in cured or fresh pork during chill or frozen storage (1), but were not associated with any noticeable off-flavour in the dehydrated product. Again, no relation between peroxide oxygen values and fluorescence values was evident.

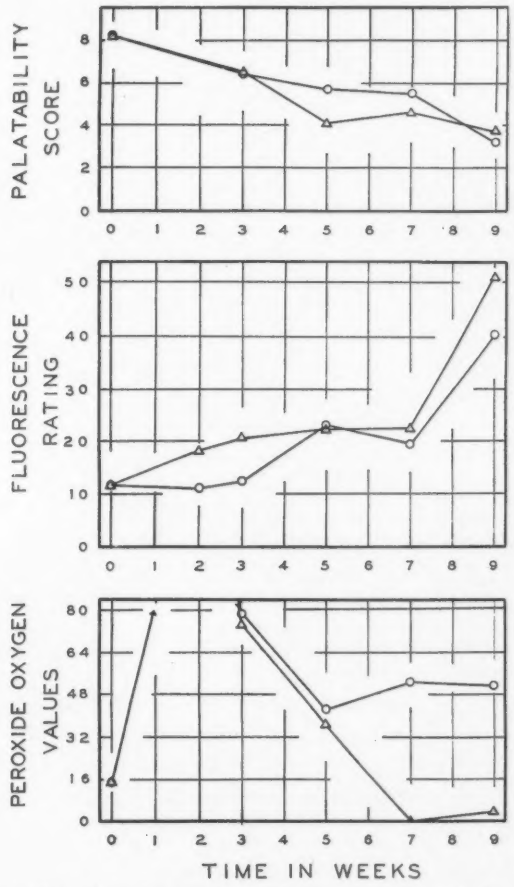

FIG. 2. *Palatability, fluorescence, and peroxide oxygen changes occurring in stored dehydrated pork. Storage temperatures: △ 37.8° C. (100° F.); ○ 23.9° C. (75° F.).*

Soya flour was the only material studied in which fluorescence values developed almost uniformly at the three temperatures studied (Fig. 3). Therefore while fluorescence development occurs it is unlikely that this measurement will be of value in predicting quality, unless temperature effects are of no consideration. The peroxide oxygen value of soya flour after 15 weeks' storage at 47.7° C. (118° F.) was 0.9 ml., all other samples having zero values.

While fluorescence development occurred in each of the high protein foods studied, only for dehydrated pork did it appear likely that fluorescence would prove useful as a measure of quality. There appeared to be no relation between fluorescence development and peroxide oxygen changes in the fatty fraction of these foodstuffs.

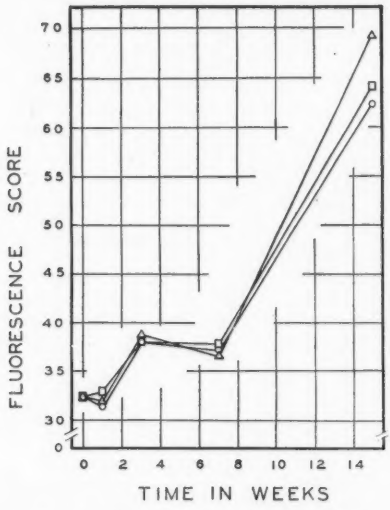

FIG. 3. *Fluorescence changes occurring in stored soya flour. Storage temperatures:* □ *47.8° C. (118° F.);* △ *37.8° C. (100° F.);* ○ *23.9° C. (75° F.).*

High Carbohydrate Foods

In both dried bananas and dried parsnips (Fig. 4), fluorescing materials increased during storage, and the rate of increase in fluorescing substances was more rapid as the temperature was increased. In both cases fluorescence increase was accompanied by noticeable browning of the stored material, the browning being more pronounced at the higher storage temperatures. While no other measurements were made on these materials, it seems likely that fluorescence increase might be a test of quality of stored carbohydrate foodstuffs.

Fats

For most of the shortenings studied, any change in fluorescence value occurring during 15 weeks' storage at 37.8° C. (100° F.) was smaller than the variability in the determination with the single exception of hydrogenated linseed oil (Table II). In this material fluorescence decreased with increased storage time. Reversion to the odour of linseed oil had begun in the hydrogenated linseed oil after only one week's storage and increased in intensity with increased storage time. It may be that this can be followed objectively by measuring the decrease in fluorescing substances.

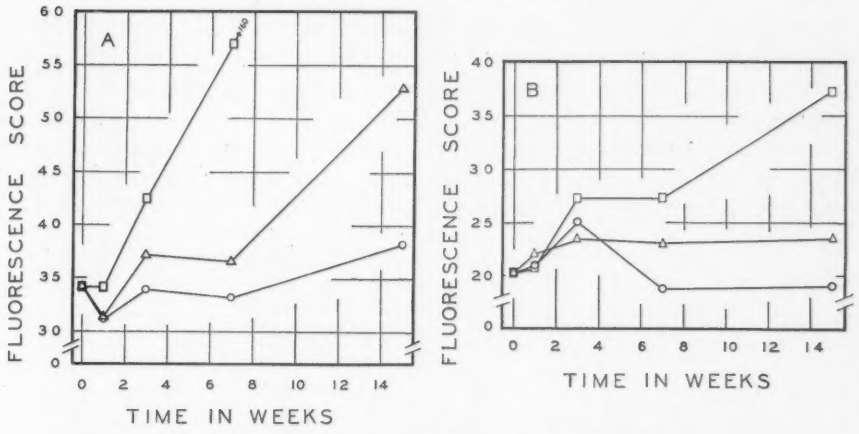

FIG. 4. *Fluorescence changes occurring in stored dried banana flakes (A) and dried parsnips (B). Storage temperatures: □ 47.8° C. (118° F.); △ 37.8° C. (100° F.); ○ 23.9° C. (75° F.).*

TABLE II

FLUORESCENCE CHANGES OCCURRING IN FATS STORED AT 37.8° C. (100° F.) COMPARED WITH RANCIDITY DEVELOPMENT

Type of fat	Fluorescence values		Peroxide oxygen value after 15 weeks*	Rancidity detected organoleptically after:
	Initial	After 15 wk.		
Hydrogenated linseed oil	67.4	52.6	0	—**
Hydrogenated vegetable	60.0	60.5	9.0	15 wk.
Hydrogenated vegetable	40.2	38.7	27.0	15 wk.
Hydrogenated vegetable, stabilized	40.2	42.8	5.6	
Hydrogenated vegetable, stabilized	38.6	38.2	0	
Hydrogenated vegetable, stabilized	60.0	61.4	6.1	
Compound hydrogenated vegetable	44.8	43.6	22.5	15 wk.
Compound hydrogenated vegetable, with Formula C	44.1	41.7	67.4	15 wk.
Compound hydrogenated vegetable, stabilized	36.3	38.1	14.9	
Mixed animal and hydrogenated vegetable	48.8	48.1	(9.2)*** 13.1	7 wk.
Mixed animal and hydrogenated vegetable	38.6	34.8	13.8	
Lard	28.0	30.2	(22.8)***38.5	7 wk.

* *Initial peroxide oxygen value zero ml. 0.002 N thiosulphate per gm. of fat in all cases.*

** *Linseed oil reversion noticeable after one week's storage.*

*** *Values in parentheses for seven week period when rancidity first detected organoleptically.*

A further possibility of applying fluorescence measurements was indicated in the course of work on fresh and rancid butter. Butter serum diluted in the proportion of 1 ml. of serum to 20 ml. of 10% potassium chloride solution gave the following fluorescence readings: fresh butter, 28.2; rancid

butter, 60.0*. It must be remembered, however, that butter serum would probably contain only protein material and water-soluble breakdown products of the fats.

Ration Biscuits

As mentioned previously biscuits were selected as combining each of the three types of foodstuffs considered above. Only fluorescence measurements were made on these materials; the results are shown in Fig. 5. There are

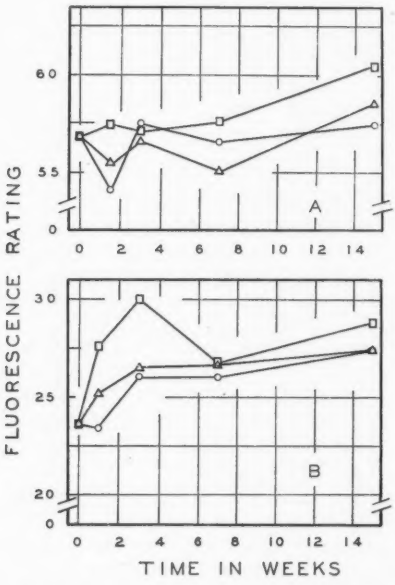

FIG. 5. *Fluorescence changes occurring in stored emergency ration biscuits. A—contains soya flour; B—contains milk powder. Storage temperatures:* □ *47.8° C. (118° F.);* △ *32.2° C. (90° F.);* ○ *23.9° C. (75° F.).*

large initial differences between the two types of biscuits, indicating that this measurement might prove valuable in detecting subtle initial differences in biscuits, such as, differences in components, or differences in processing, e.g., baking temperatures. The trends of the curves with storage time at the different temperatures indicated considerable variation in samples of biscuits. In spite of this variation, for both types of biscuits there appears to be a slight increase in fluorescing substances with storage time (1 to 5 photofluorometer units) and this increase appears to be most pronounced at the highest temperature. Although these results showed no great promise, this method was observed to be useful in subsequent studies on the keeping quality of biscuits (5).

* *Values kindly contributed by Mr. G. A. Grant of these laboratories.*

Discussion

Only a limited number of materials was investigated in the survey described here. However, this survey does indicate that fluorescence development is not peculiar to dried whole egg powder, nor is it confined to materials of high protein content. It is evident that fluorescence measurements are not likely to be a satisfactory quality test for dried milk powder or soya flour but may prove useful as a measure of quality for dehydrated pork, dried banana, dried parsnips, ration biscuits, and butter. This test may also detect reversion in hydrogenated linseed oil shortening.

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